

# REPORT DOCUMENTATION PAGE

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4. TITLE AND SUBTITLE OF REPORT Instrumentation for Coastal Transport Studies			5. FUNDING NUMBERS G-N00014-95-1-0198	
6. AUTHOR(S) William J. Wiseman, Jr. and Stephen P. Murray				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Coastal Studies Institute Louisiana State University Baton Rouge, LA 70803			8. PERFORMING ORGANIZATION REPORT NUMBER: Proposal #5721	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Mark J. Kurzius, Grants Officer Department of the Navy, Office of Naval Research 800 North Quincy Street Arlington, VA 22217-5660			10. SPONSORING/MONITORING AGENCY REPORT NUMBER:	
11. SUPPLEMENTARY NOTES:				
12a. DISTRIBUTION AVAILABILITY STATEMENT "Unlimited"			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)  To improve the capabilities of the Coastal Studies Institute personnel to collect data on the full three-dimensional structure of the water column from ships of opportunity, we requested assistance in acquiring three pieces of instrumentation: an acoustic doppler current profiler, an attitude and position determination system and a portable bench salinometer. All three pieces were purchased and deployed on a field project in the Strait of Bab-al-Mandab and the Southern Red Sea. This project is designed to determine the annual cycle of mass, salt and heat transport through the strait, determine factors governing the outflow of deep Red Sea water through the strait, determine factors governing the scale-dependent forcing of inflow and outflow, and determine the hydrographic characteristics of water transiting the strait.				
14. SUBJECT TERMS acoustic doppler current profiler, 3-dimensional global positioning and attitude determination system, portable bench salinometer, deployed on a field project in the Strait of Bab-al-Mandab and the Southern Red Sea			15. NUMBER OF PAGES: 13	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT: Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT	

# **FINAL REPORT**

**AWARD NUMBER N00014-95-1-0198**

## **INSTRUMENTATION FOR COASTAL TRANSPORT STUDIES**

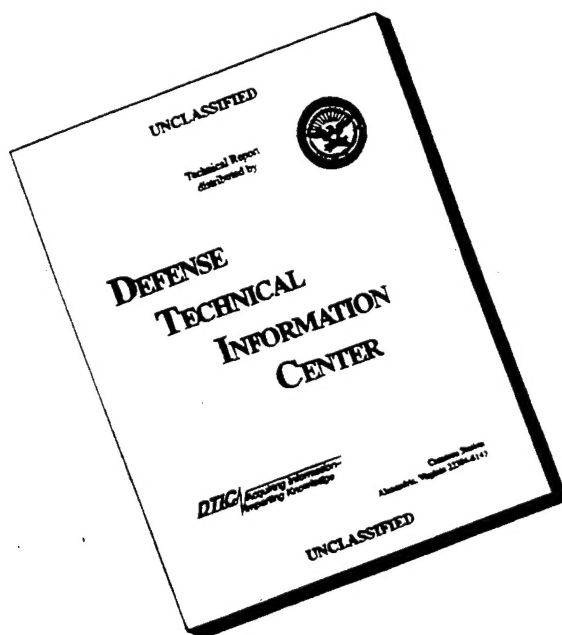
**Principal Investigators:**

**Wm. J. Wiseman, Jr.  
Stephen P. Murray**

**19960604 079**

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## INTRODUCTION

In our original proposal, we were awarded \$117,080, to be matched by \$30,000 of LSU funds, in order to acquire three equipment systems for coastal transport studies: an acoustic doppler current profile system, a three-dimensional global positioning and attitude determination system, and a portable precision salinometer. These instrument systems were meant to facilitate our operations from ships of opportunity in both national and foreign waters. The three systems have been acquired (see Appendix 1 for specifications, costs, and copies of purchase orders). The total cost was \$150,405. The increase above the originally proposed budget was supplied by LSU.



LOUISIANA STATE UNIVERSITY

AND AGRICULTURAL AND MECHANICAL COLLEGE

*Coastal Studies Institute*

*Center for Coastal, Energy & Environmental Resources*

March 27, 1996

Dr. S. R. Ramp:  
Office of Naval Research  
Ballston Tower One  
800 North Quincy Street  
Arlington, Virginia 22217-5660

Dear Dr. Ramp:

I have enclosed three (3) copies of the final report concerning Grant Number N00014-95-1-0198. Dr. Murray and I appreciate your continued support of the research program at the Coastal Studies Institute. If further information is required, please contact either Dr. Murray or myself. I regret any inconvenience the delay in providing this report may have caused at your office.

Sincerely,

Wm. J. Wiseman, Jr.  
Professor and Director

## UTILIZATION OF EQUIPMENT

All three items purchased under this DURIP proposal were immediately put into use in a major ONR sponsored investigation of the Circulation in the strait of Bab al Mandab in the southern Red Sea in May-June 1995.

The acoustic doppler current profiler (ADCP) was attached to a 185 foot chartered vessel the M/V Argo Service via a heavy duty out board boom fabricated in our laboratories/shop and shipped out to the Middle East. The Ashtec ADU was mounted in a square array on the ship and provided unprecedented accuracy in ship heading (orientation) which allowed highly accurate calibration of the ADCP data set.

The third item, the portable salinometer, was also employed in the Red Sea experiment. Its use allowed us to maintain a running calibration on the Sea Bird CTD during the 51 stations of the CTD measurement program.

The study area is shown in Figure 1. Survey lines consist of one along channel (centerline) section and six across channel sections, A through F. Figure 2 displays the along strait component of the current as measured by the ADCP on a 12 hour transit from north to south along the centerline. Note that despite the strong modulation ( $\pm 50$ cm/sec) of the semi-diurnal tide the two layer flow structure is readily apparent. The ADCP we purchased under DURIP operated in bottom track mode nearly everywhere in the Strait and, as a result, the data quality is excellent.

Figure 3 shows that the lower layer outflow mapped by the ADCP coincides with the high salinity Red Sea Deep Water as it escapes across the sill into the Gulf of Aden.

Although it malfunctioned during the last third of the cruise, we obtained excellent results from the ship-mounted broad-band ADCP, (over 90% data recovery in bottom tracking mode). Indirect estimates of the transport of Red Sea water through the Bab al Mandab Strait suggest an annual mean transport of 0.33 Sv (Sielder, 1968), varying from approximately 0.6 Sv in winter to nearly zero in late summer (Patzert, 1974). Our findings from the June 1995 cruise indicate that strong outflow conditions were still in force as of early summer (Fig. 4).

Outflow velocities in excess of 1 m/s were observed at the B-section with salinities greater than 40 filling the deep channel below 80 m (Fig. 5). Weaker inflow occurred above this layer. Our preliminary estimate of the net outflow transport is 0.5 Sv, typical of wintertime conditions. These results call into question the conclusion by Neumann and McGill (1962) that Red Sea Deep Water is completely trapped below sill depth during the entire summer season, from approximately June to September. A curious feature of the velocity distribution in Figure 4, which to our knowledge has not been observed before, is the maximum in outflow intensity near the top of the Red Sea Deep Water layer, rather than at the bottom. This suggests that even though a strong outflow is occurring, much of the outflow at this time is composed of intermediate salinity waters that represent a mixing product between the Red Sea Deep Water and fresher waters flowing in from the Gulf of Aden.

## **FUTURE PLANS**

All three items of equipment will again be utilized in the Red Sea Strait of Bab al Mandab study in March-April 1996, and again in October 1996. The Ashtec ADU will be returned to LSU during the summer for use with a new very shallow water (~ 10 m) ADCP we are acquiring. The portable salinometer will also be returned to process samples from local studies.

Results of measurements using this instrument were presented at the 1996 AGU Ocean Science Meeting; Murray, S.P. and W. Johns, Exchange Processes through the Bab al Mandab Strait. First look, EOS, Trans. Amer. Geophysics. Union U. 76, No. 3, abs 055J-9, and more recent results will be presented at Western Pacific AGU meeting in July in Brisbane.

# Red Sea, Cruise 1, CTD #

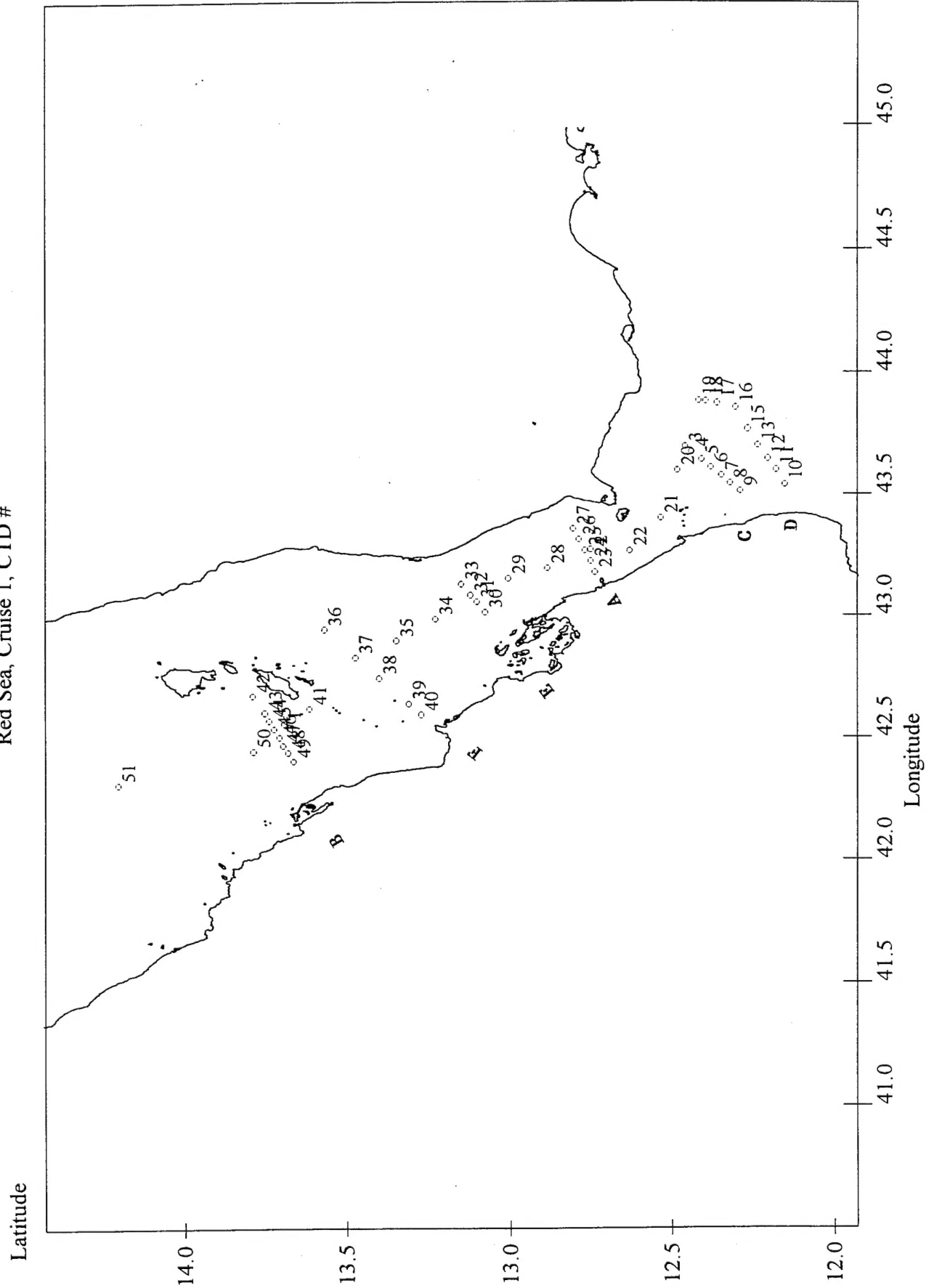


FIGURE 1. Stations and sections in Bab al Mandab study area.



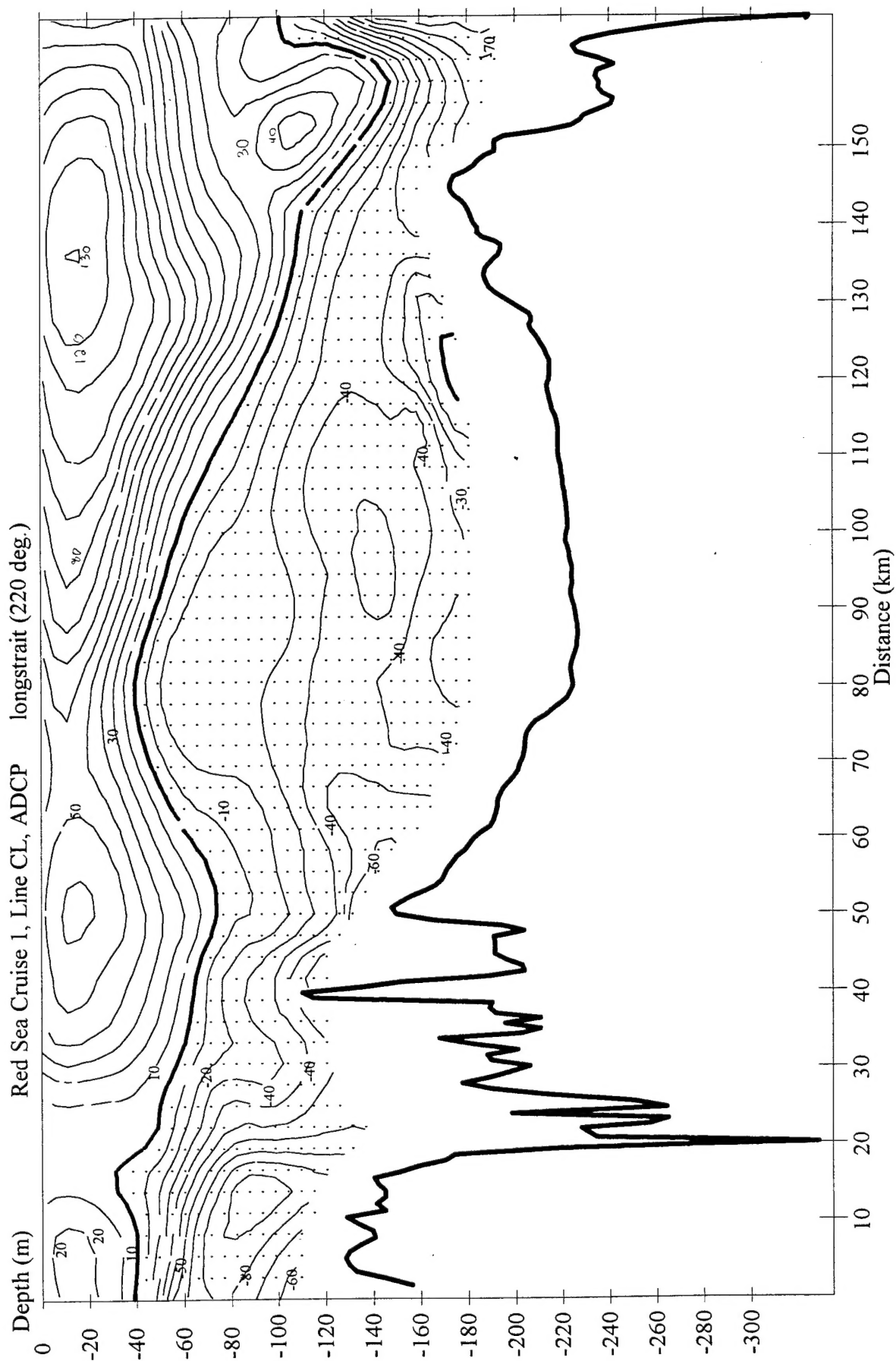


FIGURE 2. Along-strait component of current from the ADCP along the channel centerline.

# Red Sea Cruise 1, Line CL, Salinity

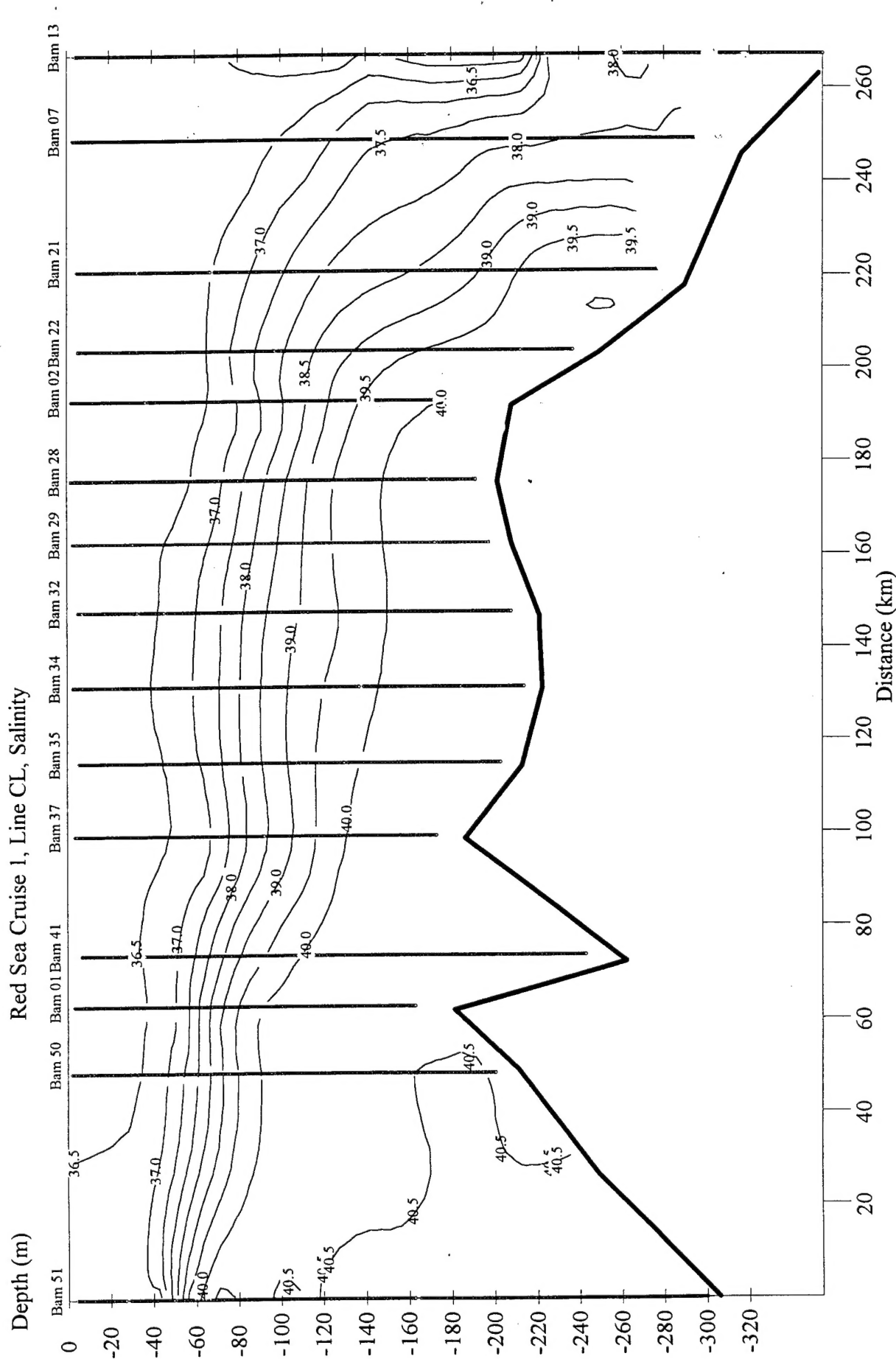


FIGURE 3. Salinity distribution along the centerline of the channel.

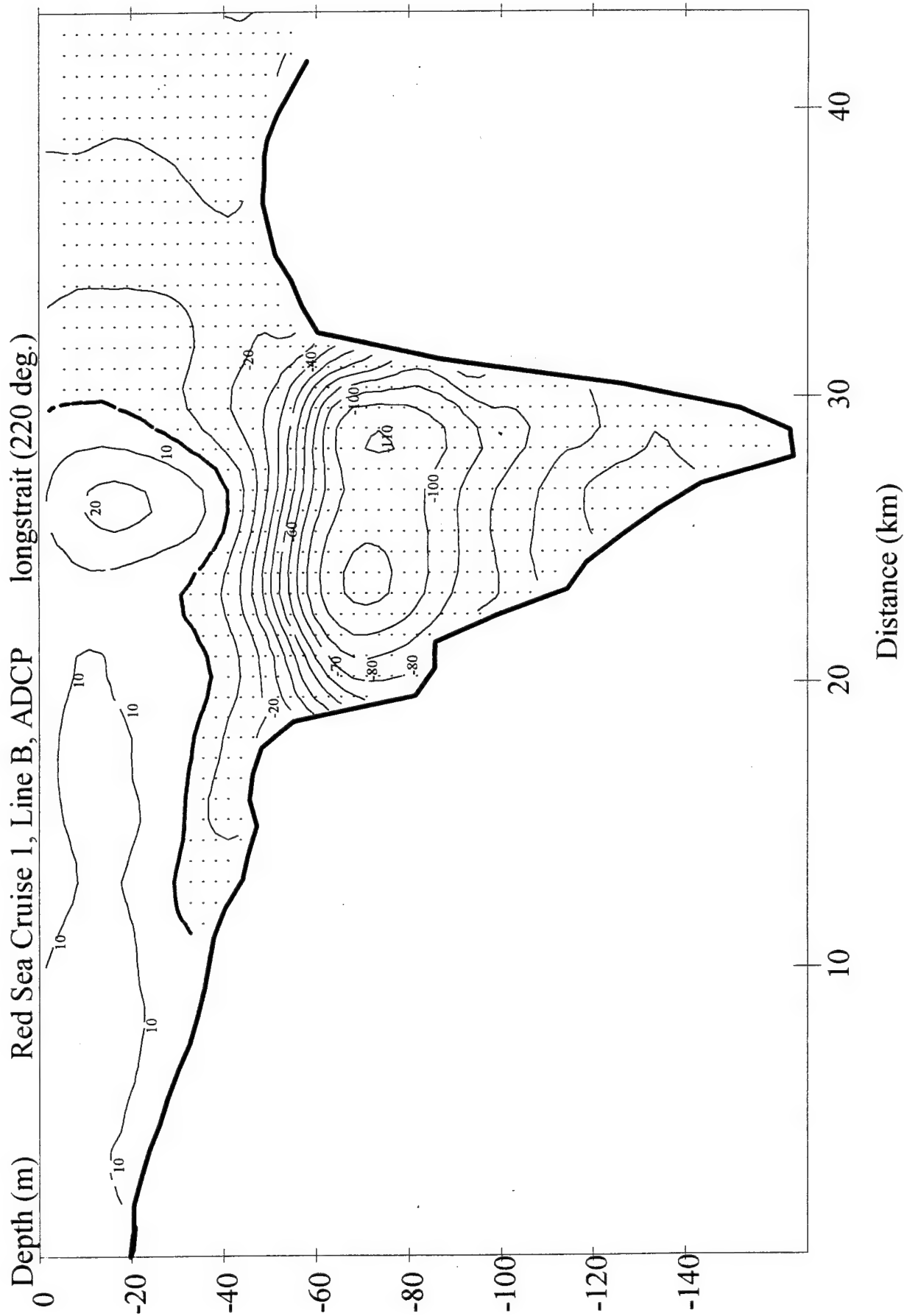


FIGURE 4. Along-strait component of ADCP current at section B.

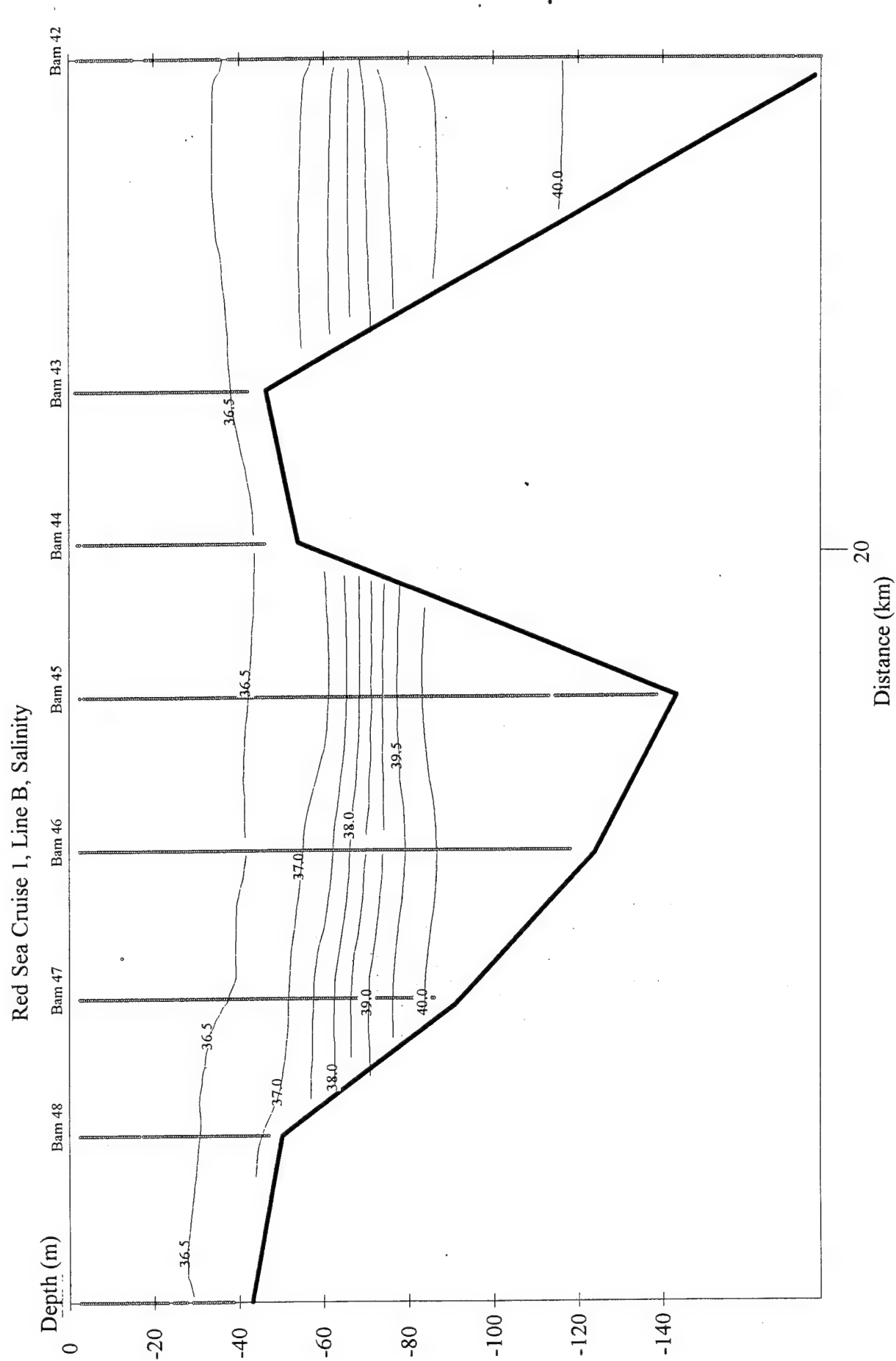


FIGURE 5. Salinity along section B.

# APPENDIX

1.	Acoustic Doppler Current Profiler System	
	Broad band acoustic doppler current profiling system	\$ 64,160
	Spare printed circuit boards	12,280
	600 khz transducer head	20,710
	Power Timing board	5,520
	Demodulator boards (2)      \$2,820/ea.	5,640
	Special modification to underwater case	3,000
	GYRO interface	4,310
	Total	\$115,620

Rd Instruments, Inc.  
9855 Businesspark Ave  
San Diego, CA 92131

2.	Three-dimensional global positioning and attitude determination system	\$ 17,800
	Real-time differential GPS option	1,500
	Total	\$ 19,300

ASHTECH, INC  
1170 Kifer Road  
Sunnyvalley, CA 94086

3.	Portable precision salinometer	\$ 12,995
	Digital platinum resistance reference thermometer	2,490
	Total	\$ 15,485

Guildline Instruments, Inc.  
103 Commerce Street, Suite 160  
Lake Mary, FL 32795-2590

GRAND TOTAL	\$150,405
-------------	-----------

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COASTAL STUDIES INST.  
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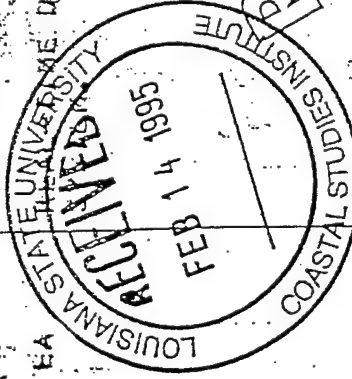
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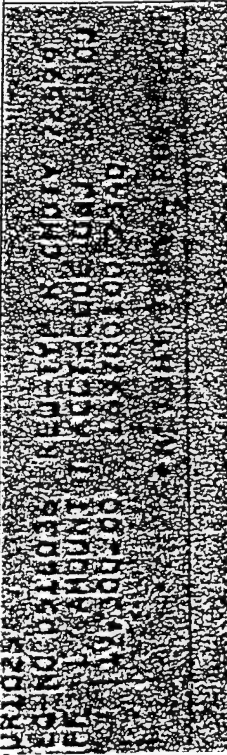
ENDOR NUMBER: 92033

REMARKS: BID #05F000973

ITEM	QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	EXTENDED AMOUNT
01	1	EA	3 DIMENSIONAL GLOBAL POSITIONING AND ATTITUDE DETERMINATION SYSTEM, ASHTECH 3DF GPS AOU RECEIVER. SYSTEM TO INCLUDE: 24 CHANNELS C/A CODE AND CARRIER, IPPS, RAW DATA, 1/2 SECOND UPDATE, EXTERNAL PORTS RS-232 CONNECTOR, RECEIVER OPERATING MANUAL, 3DF INSULATION/ CALIBRATION SOFTWARE INCLUDING: MISSION PLANNING, STATIC/DYNAMIC CALIBRATIONS, AND VECTOR ADJUSTMENT. ONE YEAR FIRMWARE UPDATES, AND ONE YEAR WARRANTY.	17,800.00	17,800.00
02	1	EA	RECEIVING REPORT	1,500.00	1,500.00



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EM	QUANTITY	UNIT	REMARKS	SENT TO	UNIT PRICE	EXTENDED AMOUNT
J1	1	EA ✓	ERUAD BAND ACUSTIC PROFILEING SYSTEM MAY 23 1995 ROI DIRECT READING MODEL DR-150-HP	30000.00	30000.00	64,100.00
J2	1	EA ✓	SPARE PRINTED CIRCUIT BOARD FOR WSPCH-800	12,200.00	12,200.00	12,200.00
J3	1	EA ✓	500 KHZ TRANSDUCER HEAD FOR CONVERTING SYSTEM TO 500 KHZ OPERATION, ROI PART #PI-HF	20,710.00	20,710.00	20,710.00
J4	1	EA ✓	POWER TIMING BOARD NECESSARY FOR CONVERTING KHZ SYSTEM FOR 500 KHZ OPERATION, ROI PART #PI-HF	5,520.00	5,520.00	5,520.00
J5	2	EA ✓	DEMODULATOR BOARD NECESSARY FOR CONVERTING 150 KHZ SYSTEM FOR 500 KHZ OPERATION, ROI PART #DEHGD-HF	2,820.00	2,820.00	5,640.00
J6	1	EA ✓	SPECIAL MODIFICATION TO UNDERWATER CASE - REDUCTION OF CONNECTOR END, XX END CAP FROM STANDARD 8.00 DIA TO 7.25 DIA. AT TIME OF MANUFACTURE TO MAINTAIN ANODIZING AND ELECTRO-INSULATION OF CONNECTING HARDWARE. ROI PART #SPECIAL	3,000.00	3,000.00	3,000.00

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VENDOR NUMBER: 133149  
 REMARKS: BSCSN0974  
 DESCRIPTION

ITEM	QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	EXTENDED AMOUNT
7	1	EA	GYRO INTERFACE FOR ITEM #6 WECKNOX (ONE SYNCHRO) ROI PART #6Y1-D-1.	4,310.00	4,310.00

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1 1 EA PORTABLE PRECISION SALINOMETER FOR ACCURATE SAMPLE DETERMINATION OF CONDUCTIVITY RATIO AT PRECISE TEMPERATURES AND DISPLAY OF CALCULATED SALINITY. BUILDING MODEL 8440 "PORTASAL"

2 1 EA DIGITAL PLATINUM RESISTANCE REFERENCE THERMOMETER FOR ITEM #1, GUILDLINE MODEL 9540.

12,995.00

12,995.00

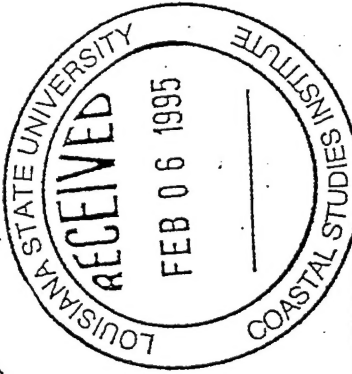
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Please see that the attachment is resubmitted directly to DTIC, together with a properly completed SF 298. The new DTIC address is 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218. Please ensure block 12a, "Distribution Availability Statement", of the SF 298 is marked "Unlimited" or it will be returned by DTIC.

Also, please circulate the SF 298 to the researchers at your institution who work on Department of Defense contracts, grants, and cooperative agreements, so that it's use will become the standard for submitting an interim or final technical report to DTIC. We also ask that you continue to include the appropriate ONR office on the distribution for all future interim and final reports. A properly completed SF 298 is sufficient in lieu of a complete copy of the report..

Your assistance is greatly appreciated. If you have any questions, please contact the undersigned at (404) 730-9261.

Sincerely,

APRIL J. MILLER  
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